



Written Assignment 2

Introduction To Computer Systems (Carnegie Mellon University)



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15-213: Introduction to Computer Systems

Written Assignment 2

Learning Objectives

- Recall the format of IEEE floating point representations.
- Convert between IEEE floating point representations and base 10.
- Interpret information access in machine-level code
- Write arithmetic operations in machine-level code

Directions

Complete the question(s) on the following pages with single paragraph answers. These questions are not meant to be particularly long! Once you are done, submit this assignment on Canvas.

An example question and answer is provided below.

Q: Explain why the granularity of floating point numbers increases the closer their values are to 0 (i.e. why are floating point numbers “denser” the closer they are to 0). Compare the granularity of denormalized floating point numbers with the smallest normalized floating point numbers.

A: As the encoded exponent becomes smaller, the magnitude of the fraction bits decrease, but there are still the same number of representable values with that exponent. For example, take an 8-bit floating point number with 3 exponent bits and 4 fraction bits. For each exponent value, there are 2^4 representable values. With an encoded exponent of 2, these differ by 2^{-2} ($1/4$) each. However, with an encoded exponent of -2, there are still 2^4 representable values, but each value differs from the one above and below it by 2^{-6} ($1/64$). Because the smallest normalized floating point numbers have the same encoded exponent as the largest denormalized floating point numbers, denormalized floating point numbers are twice as granular as the smallest normalized floating point numbers, even though denormalized floating point numbers have an implicit leading 0 instead of a leading 1.

Grading

Each assignment will be graded in two parts:

1. Does this work indicate any effort? (e.g. it's not copied from a homework for another class or from the book)
2. Three peers will provide short, constructive feedback.

Due Date

This assignment is due on Wednesday September 23, 11:59 PM EST. Remember to convert this time to the timezone you currently reside in.

Question 1

Consider the IEEE floating point standard. Numbers in this format come in three different cases: normalized, denormalized, and special values. Explain the characteristics and purpose of each case (such as, how does it add utility? What would the floating point standard lose without it?) in 1-2 sentences each and give an example of a 32 bit single precision floating point number of your choice. Include the bit representation and base 10 representation when possible.

Single precision: 32 bits
 ≈ 7 decimal digits, $10^{\pm 38}$



Normalized:

Denormalized:

Special Values:

Question 2

Goran G is working on a class programming project. He has decided that C programming is too mainstream and instead chooses to develop in assembly code. When Goran invokes the assembler, he gets error messages. Looking at his code, find out which lines generate errors and explain what is wrong. Justify and explain your thought process in solving this problem. Assume that the assembly code follows AT&T syntax: `movq src, dest`.

```
1  gorans_function:
2      movq (%rdi), %rax
3      movb $0xAA, %dl
4      movl %eax, %rdx
5      movq %rsi, (%rdi)
6      movq %rdx, $0x256
7      ret
```

Question 3

Suppose that register `%rdi` contains value x , register `%rci` contains value y , and register `%rax` contains value z . Write a `leaq` instruction that follows the formula $z = 4x + y + 3$.